THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

The world's oil industry spends more than $250 million a year in surveying subsurface conditions on land and under water by the seismic method. The mining industry likewise makes extensive use of seismic techniques. In the civil engineering field, however, these techniques are just starting to be applied as more and more engineers are becoming familiar with what seismology can do for them in determining subsurface conditions.

The refraction method of seismic survey can solve many problems which often are left unsolved or are merely estimated by the design engineer. It is now being applied successfully to the solution of foundation problems involved in the construction of power plants, dams, tunnels, subways, highways, bridges, and other projects where the depth to bedrock, the type of rock encountered, and the characteristics of the overburden material are important.

A description of the refraction method of seismic survey is given in the article "Engineering Seismology," beginning on page 167.

* * *

Strip mining coal around a mountainside at a location 700 ft. above the base of the mountain has been in successful operation since 1948 by Central Pennsylvania Quarry, Stripping and Construction Company, under contract with Westmoreland Coal Company. Work on the project, known as Hampton Mines Stripping, is being done in an undeveloped area of 10,500 acres of land in southern West Virginia.

A winding roadway, 3 miles long, had to be constructed up rugged, mountainous terrain to provide access to the area. The Chesapeake & Ohio Railroad Company built a 7-mile spur line from Clothier, West Virginia, to service the mining activities.

EDITORIAL STAFF: Joseph I. Horty, *Editor;* Gertrude A. Donnelly, *Assistant Editor;* Elizabeth M. Joyce, *Assistant Editor;* Edward L. Grant, *Art Editor;* Frank J. Canova, *Production Manager;* Charles E. Rabenold, *Advertising Manager;* Montgomery R. Budd, *Director.*

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

In the beginning, the strip-mining operations were carried on in the Upper and the Lower Hampton seams of coal. The coal in the upper seam is 6 to 7 ft. thick; in the lower seam, 5 to 6 ft. thick. After both seams were stripped, the overburden material extended to a height of 80 ft.

For blasting in the highwall, 6-in.-diameter holes, 54 to 72 ft. deep on 11-ft. centers, are drilled horizontally with a McCarthy 103 Highwall drill. Various grades and strengths of Hercules dynamites primed with short-period delay detonators are used in loading the drill holes for primary blasts.

For a summary of the operations at this unusual coal-mining project, please turn to page 172.

* * *

Thomas J. Walsh, chairman of the board of directors of Walsh Construction Company, New York City, and Carl B. Jansen, president of Dravo Corporation, Pittsburgh have been chosen to receive The Moles Awards for 1955, at the annual dinner-ceremony of the association at the Waldorf-Astoria in New York on February 2, 1955.

The awards, given annually since 1941, honor a member and a nonmember of The Moles "for outstanding achievements in the construction industry."

Further details will be found on page 177.

* * *

In our September-October, 1954, issue, we presented Part I of the article "Mining Uranium in the Colorado Plateau" in which the weird beauty of the area was described and the uranium program of the Atomic Energy Commission's Raw Materials Division was outlined.

In Part II, of the article, which begins on page 178, additional price guarantees and bonus payments by the AEC are given; the leasing of land for exploration is described; and drilling and blasting techniques are presented. Also included is an account of the phenomenal success story of Charles Steen and his development of the fabulous Utex Mine near Moab, Utah.

Please turn to page 178.

GYRO-FLO
ROTARY COMPRESSORS

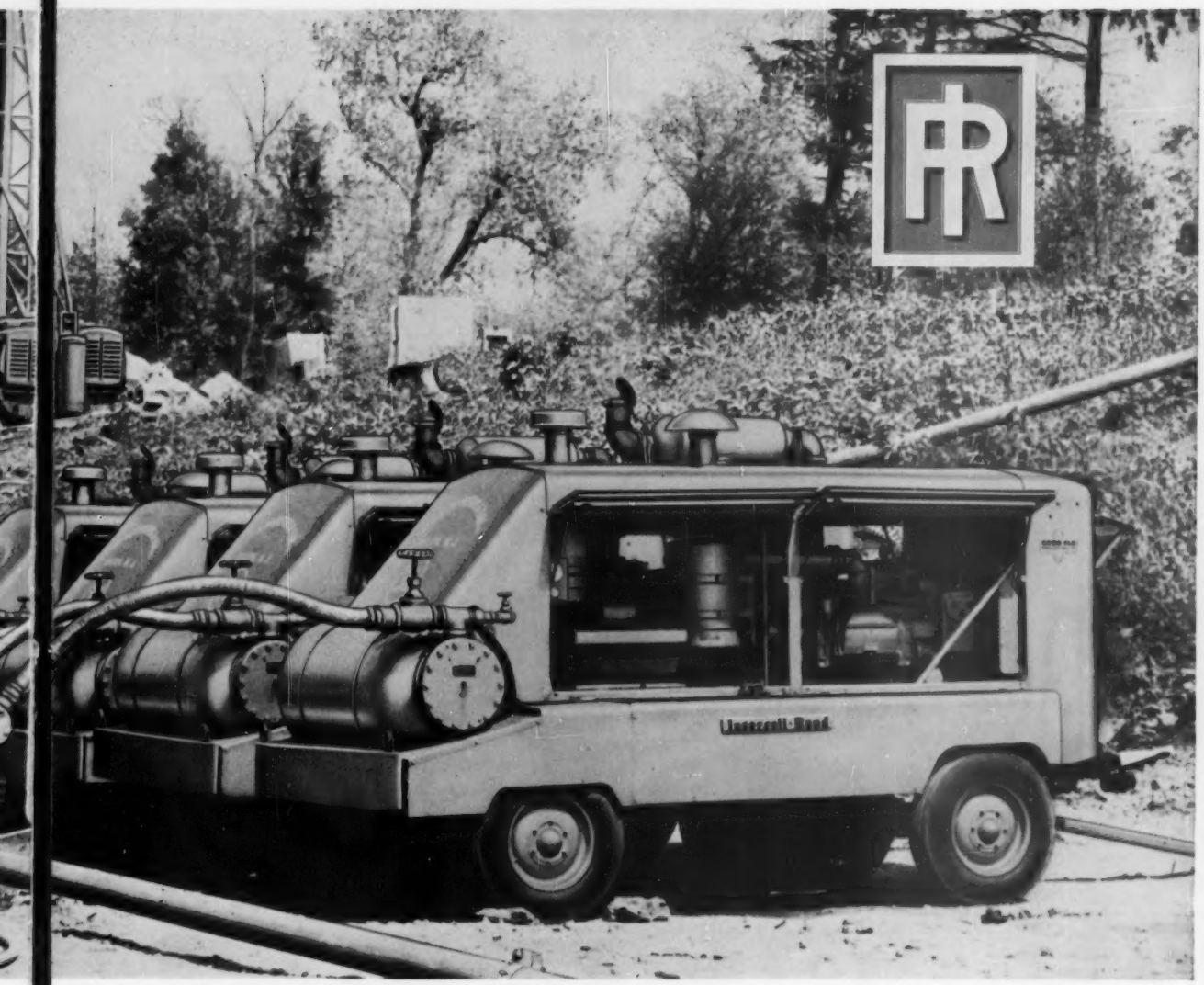
117 units speed construction of the New York Thruway

These four 600 cfm **GYRO-FLO** portables supply ample air power for operating up to eleven I-R wagon drills on one section of the New York Thruway. Air from a common receiver is piped 700 to 800 feet to the drilling site through a 6″ line. In the background is a completely self-contained I-R Quarrymaster for sinking large, deep blast holes.

Here, an I-R **GYRO-FLO** supplies abundant air for operating a pneumatic pile hammer, driving sheet piling for construction of one of the Thruway's many bridges.

The **GYRO-FLO** compressor has repeatedly proved its ability to operate continuously under all types of working conditions, with a trouble-free dependability and easy portability heretofore not obtainable in any portable air compressor.

These compressors furnish air to users of 173 Ingersoll-Rand Type FM Wagon Drills—more than 70% of the total wagon drills on this project.



By early 1955, you'll be able to drive from New York City to Buffalo—without a single traffic light or stop sign. That's the fabulous New York Thruway, a dream that I-R Air Power is helping to carve out of rugged terrain where many sections are solid rock.

One hundred seventeen GYRO-FLO rotary compressors, with a combined capacity of 61,265 cubic feet of air per minute, are speeding the job to completion—driving Ingersoll-Rand rock drills and other pneumatic equipment on this high-speed construction project.

Here, where sustained drilling speed and uninterrupted production are of particular urgency, the simplicity and dependability of the GYRO-FLO design really pay off. The GYRO-FLO rotary sliding vane compressor has no valves, pistons, rings, rods or clutches to wear out, adjust or replace. It delivers an abundant supply of oil-free air at temperatures that never go above 200 F. And pressure is automatically controlled closely and smoothly all the way from 0 to 100% capacity.

Available in 125, 210, 315 and 600 cfm, GYRO-FLO offers the only complete line of rotary portables—each size proven by years of heavy duty in the field. Get the complete GYRO-FLO story from your nearest Ingersoll-Rand distributor or branch office. It will save you money now and for many years to come.

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WILLIAM LESTER McKNIGHT

William Lester McKnight

CHAIRMAN OF THE BOARD OF DIRECTORS

MINNESOTA MINING & MANUFACTURING COMPANY

A Biography

THE CAREER of William Lester McKnight, chairman of the board of directors of Minnesota Mining & Manufacturing Company, parallels the growth and development of the company to a remarkable degree. The company known as 3M was founded in 1902 on limited capital and some borrowed funds; McKnight, a twenty-year-old youth, equipped with a six-month-completion certificate from a Duluth business school and a capacity for hard work, got a job with the company in 1907 as assistant bookkeeper. During the intervening years, 3M's annual sales climbed from a few thousand dollars to $220 million in 1953. Mr. McKnight's long-time insistence on aggressive selling, careful quality control, and continuing diversification through research and product development provided the yeast that stimulated this sensational rise.

"Mac," as he is known to his friends and associates, was born November 11, 1887, on a farm near White, South Dakota, the son of Joseph and Cordelia (Smith) McKnight. He completed his formal education at Duluth Business University. His choice of the school in Duluth was influenced by two factors: it guaranteed to find a job for him upon completion of its business course; he could live with relatives and thereby keep his living expenses at a minimum.

Two years after joining the firm, William McKnight was sent to Chicago to manage a small branch office. In 1911 he was named company sales manager and continued to headquarter in Chicago. He was named general manager in 1914 and moved to St. Paul. He was elected vice president in 1915 and was made president of the company in 1929.

As 3M's chief administrative officer, Mr. McKnight not only guided the company safely through the depression years but established its business on a firmer foundation. The measurement of his contributions are reflected in the following statistics: in 1933, sales were $4 million; in 1938, $14 million; in 1943, $47 million; in 1948, $108 million; in 1953, $220 million. Operating plants are located in fourteen cities in the United States as well as in Canada, England, Wales, France, Germany, Mexico, Brazil, and Australia. Domestic sales are handled from twenty-two branch offices strategically located throughout the country.

In 1949 he was again honored by his company associates by being chosen to fill the newly created post of chairman of the board of directors.

In addition to being top man at 3M, Mr. McKnight is a member of the boards of directors of Midland Rubber Corporation, National Synthetic Rubber Corporation, Minnesota Mining & Manufacturing International Company, and Minnesota Mining & Manufacturing of Canada, Limited, all affiliates of the parent company. He is also a director of First National Bank of St. Paul; Northwestern Bell Telephone Company; Great Northern Railway Company; Crane Company of Minnesota; Charles T. Miller Hospital, Incorporated; and a trustee of Minnesota Mutual Life Insurance Company.

Mr. McKnight is a member of the Minnesota Club, St. Paul Athletic Club, White Bear Yacht Club, Cat Key Club of the Bahamas, Surf Club and Indian Creek Country Club of Miami Beach, the Chicago Club, and the Union League Clubs in Chicago and New York.

William Lester McKnight married Maud L. Gage on October 9, 1915, in St. Paul, Minnesota. They have one daughter, Virginia, who is married to James H. Binger, an executive of Minneapolis-Honeywell Regulator Company. The McKnight home is at 1855 Summit Avenue, St. Paul.

Mr. McKnight's principal hobbies are playing gin rummy with his friends, and deep-sea fishing from his boat in the waters off the coast of Florida.

It is often said that a man of talent grows with his company, but that a company grows with a man of genius. Associates at 3M believe William L. McKnight is a man of genius, and the record seems to prove it.

Editorial

Merry Christmas – Happy New Year

IT'S CHRISTMAS and, once again, the editorial staff of THE EXPLOSIVES ENGINEER welcomes the opportunity to extend the season's greetings and good wishes for the New Year to all of its readers and friends.

Safeguard Human Lives

In announcing the start of the National Safety Competition in January, 1925, an editorial was published in THE EXPLOSIVES ENGINEER which read, in part:

> Great though the need be for improvements in blasting practice and other mining and quarrying methods which will increase output and decrease costs, and worthwhile as is every effort toward the making of such improvements, it must be agreed that the safeguarding of human lives is even more important.

The National Safety Competition was launched thirty years ago with high hopes and laudable ideals. During the intervening years, there has been a definite decrease in the accident rate among the companies entered in this nationwide competition. That contests of this type react favorably on management and personnel is adequately proved by statistics compiled by the U. S. Bureau of Mines which emphasize the downward trend of accident-frequency rates in the mineral industry.

Industry's response to the humanitarian appeal to save life is heartening. The possibility that this response, carried to its ultimate conclusion, will conceivably result in the elimination of all disabling accidents in our mines and quarries, is particularly heartening.

As the beginning of a new year approaches, we again appeal to the operators of mines and quarries in the United States to enroll their properties in the National Safety Competition. Join the campaign today by communicating with the Bureau of Mines, Washington 25, D. C., and enroll your mine or quarry in the classification that fits your operations – coal, metal, nonmetallic, open-pit mines, and quarries.

Mineral Industries Survey Included In Government Census

Robert W. Burgess of the Bureau of Census, U. S. Department of Commerce, announced recently that approximately 3 million firms in the mining, manufacturing, and distributing industries in the United States will be surveyed during 1955, under the Censuses of Business, Manufactures, and Mineral Industries. The Congress has appropriated $8.43 million for the job, which will be done by mail. The census will cover 1954 operations.

The survey of mineral industries will include about 35,000 establishments engaged in mining, quarrying, and petroleum production.

In making the announcement, Mr. Burgess said: "The Congress has made provision for these important and timely censuses so that up-to-date statistical information may be compiled and published about American industries and trades. The demand for this information has become imperative because the latest census statistics available are from 7 to 15 years old. Both Government and private enterprise need fresher information about the nation's businesses which serve the needs of a population of nearly 163 million."

Industrial High Explosives

The United States Department of the Interior, Bureau of Mines, reports that the consumption of high explosives by industry in 1953 amounted to 758,831,000 pounds. This huge amount was an all-time high, an increase of about 3½ per cent over the previous record year of 1952.

Approximately 30 per cent of last year's production and sales was required to mine the nation's coal. Nonmetallic mines and quarries used 23 per cent; construction projects, including seismic explorations, consumed 23 per cent; the metal-mining industry required 22 per cent; and the remaining 2 per cent was used for all other purposes.

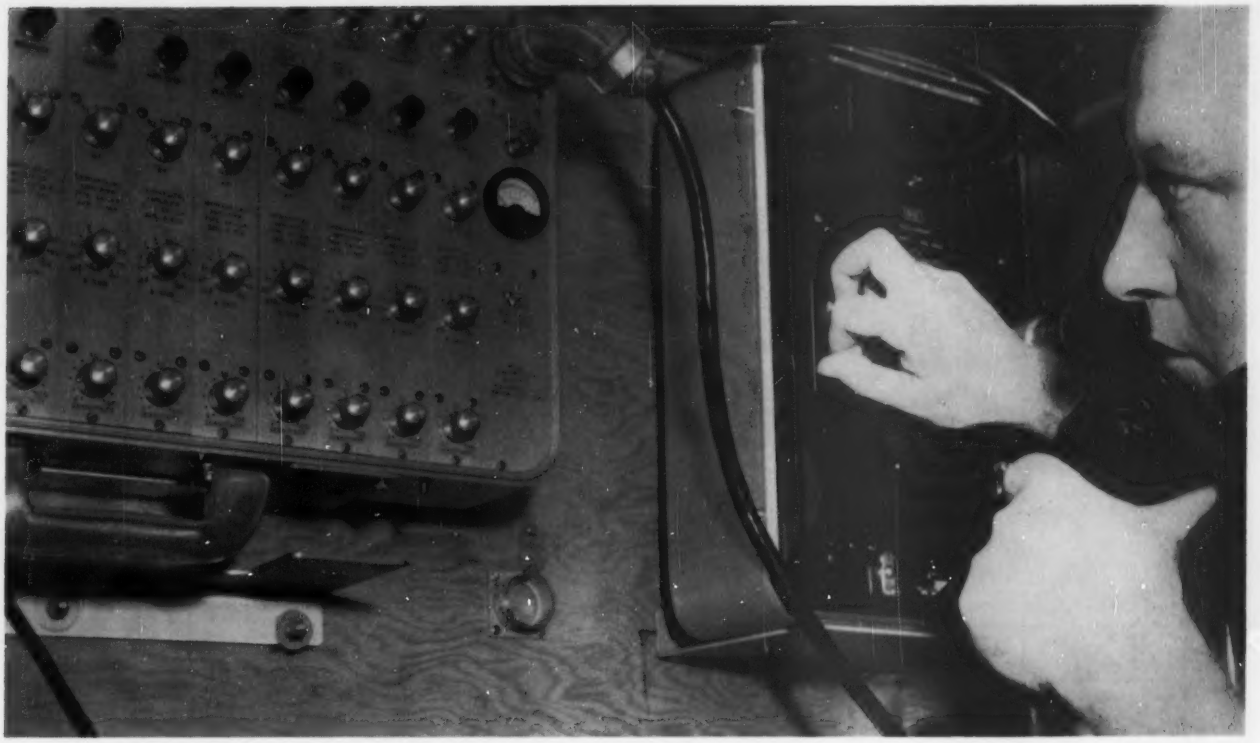
Estimates of the production and sales of high explosives for industry in 1954, as of September 30, show a decrease of about 10 per cent from the 1953 figures. The decrease is accounted for, primarily, in the sharp curtailment in coal-mining operations this year as compared with 1953 activities. The requirements of the other consumer classifications, in terms of percentage volume, have been approximately the same to date this year as in 1953.

H. A. Campbell, director and chief inspector, Bureau of Explosives, Association of American Railways, reports that 1953 marked the 32nd consecutive year in which no deaths or injuries occurred in the rail transportation of high explosives. This remarkable safety record through many years is a tribute to the individual employe of both the railroads in the United States and the manufacturers of industrial high explosives throughout the nation.

Coal Mine Modernization

The 1954 edition of *Coal Mine Modernization*, containing all of the papers and discussions presented at this year's Coal Convention of the American Mining Congress on methods, operating practices, and equipment for efficient coal production is ready for distribution.

The price for this storehouse of information on coal production is $3.00 a copy. Orders should be sent to American Mining Congress, 1102 Ring Building, Washington 6, D. C.



RECORDING SUBSURFACE CONDITIONS: A member of a seismic survey crew of the Gahagan Corporation operates instruments in the cab of a truck. The geophones are connected to the recording instruments by cable. Readings can be made to a thousandth of a second.

ENGINEERING SEISMOLOGY

As the advantages of the seismic methods are becoming more widely known, contractors and engineers are turning to seismology for the solution of their subsurface problems

E. K. SANDBACH*

THE world's oil industry spends more than $250 million annually in surveying subsurface conditions on land and under water by the seismic method of surveying. The mining industry also makes extensive use of seismic techniques. In the civil engineering field, however, it is only recently that seismological exploration techniques are being applied.

Engineering seismology can solve many of the problems which sometimes are left unsolved or are merely estimated by design engineers. As the advantages of the seismic methods are becoming better known, more and more engineers and contractors are turning to seismology for the solution of their subsurface problems.

*Vice President, Gahagan Construction Corporation
90 Broad Street, New York 4, N. Y.

The seismic survey has been successfully applied to the solution of foundation problems for buildings, power plants, dams, tunnels, highways, bridges, subways, and other construction projects where the depth to bedrock, the type of rock encountered, and the characteristics of the overburden are important. A brief description of the seismic method of surveying is presented in this article.

The Refraction Method

The refraction method of seismic survey is used to explore subsurface conditions from the ground surface down to 500 or 1,000 ft. When applied to civil engineering projects, it is concerned, usually, with shallow surveying of the first few hundred feet below the ground surface.

Primarily, the method is based on the measurement of the time of advance of a wave front generated by an explosion. This measurement is obtained by recording the arrival time of the wave front at the geophones placed on the ground at regular intervals away from the shot point. Special explosives, such as Vibrocap® SR, are required in order to time properly the arrival of the seismic waves. This instantaneous detonator, developed by

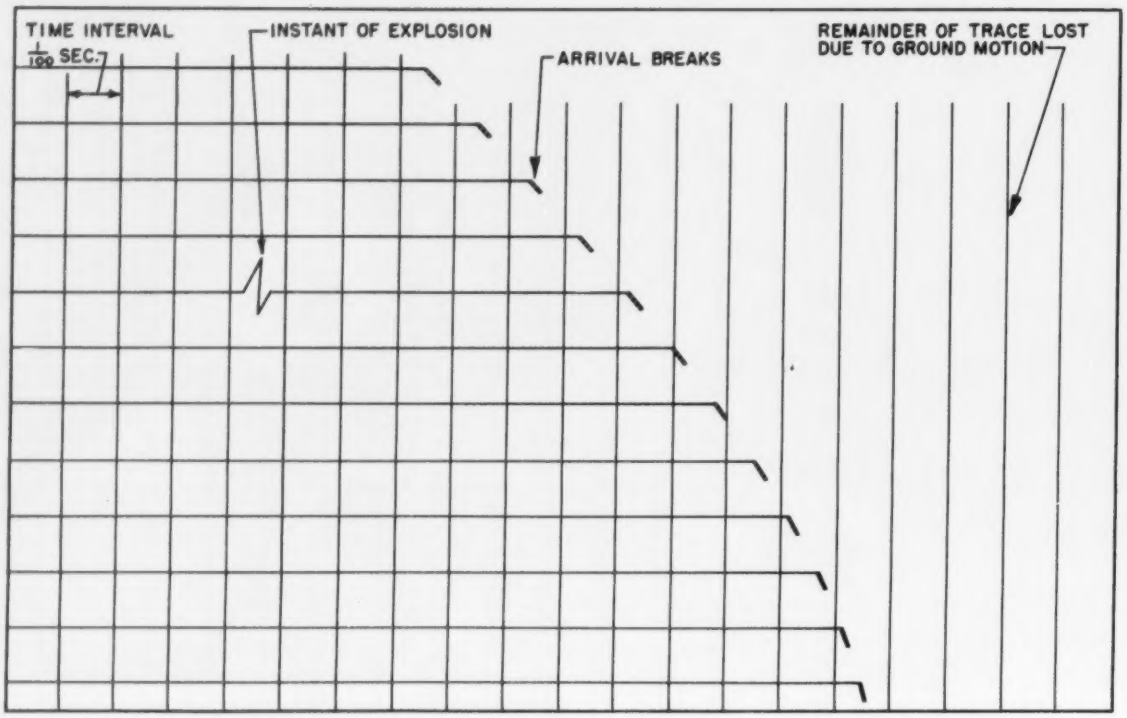


FIGURE 1: This reproduction of a siesmic record of a subsurface survey shows the instant of explosion and the arrival of the wave front at each of 12 seismometers.

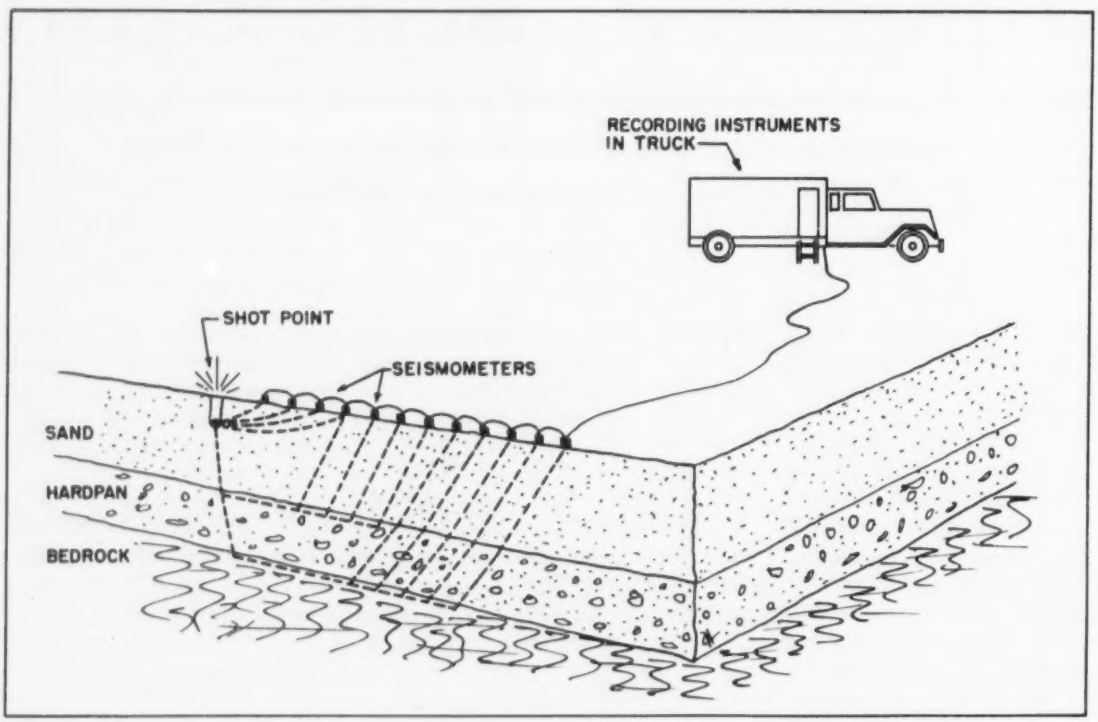


FIGURE 2: This reproduction of a drawing presents a picture, in graphic form, of the information indicated in the seismic record shown in Figure 1.

AT A SHOT POINT: In surveying subsurface conditions by the seismic method, special explosives, such as Vibrocap SR, are required in order to time accurately the arrival of the seismic waves.

Hercules Powder Company, activating an electric circuit records on the seismic record the instant of the explosion. The first arrival times of the seismic waves at each geophone are measured in milliseconds from the instant of the explosion. The transmission of these seismic waves in the earth is controlled by the same laws as the propagation of light waves. The seismic waves are refracted at any interface where a change of velocity takes place. Therefore, as the seismic waves penetrate the earth they are refracted by materials of differing velocities. The travel times for the different types of material between the shot point and the geophones give the velocities of the various materials.

Figure 1 is a typical layout of a so-called three-layered problem, one in which three types of material have been encountered, each with a progressively higher velocity. The geophones are connected by cable to the recording instruments, which are truck-mounted. For work in rough terrain, the instruments can be readily removed from the truck and carried anywhere a man can walk. A high-speed camera records on paper the instant of firing a charge of explosives and the time of arrival of the first sound wave at each instrument. As the instruments are placed at known distances from the shot point, and from one another, and as the camera records the time of arrival at each instrument, the velocity of the material recorded at each instrument is known. For example, if the geophones are spaced 50 ft. apart and it takes 1/100 of a second for the sound to reach the first instrument, the velocity recorded is 50 x 100, or 5,000 ft. a second. The spacing of the vertical time lines on the recording paper is 1/100 of a second. Readings can be made to a thousandth of a second.

The depth calculations are based on the time-distance analysis of the recordings by each geophone. The depth so calculated will be that depth under the shot hole. The pattern is then reversed by leaving the cable in place and firing an explosives charge at the opposite end of the spread. Thus, with the depths at each end of the spread known, the average depth of the strata is known. Although there may be some irregularities in the bedrock surface, any major irregularities will be found in the interpretation of the data received, and may call for additional spreads, depending on the problem.

Instrument Spread

The type of instrument spread is determined by the problem to be studied. If a detailed survey of the bedrock is required, instrument spacing will be closer, and a closer grid will be used. If, on the other hand, only an average depth of the rock is wanted, a wider spacing between geophones is used, with a result that more linear feet of profile may be obtained each day. The depth of the bedrock also determines the length of spread to be used, since that length is approximately three times the depth of the rock.

The so-called "spread" is a series of 12 geophones placed an equal distance apart. If 10-ft. spacing is used, the spread will be 110 ft. long; if 20 ft., it will be 220 ft. long; and if 50 ft., 550 ft. long. By using continuous spreads and using the same shot holes for adjacent spreads, a continuous profile is obtained and the interpreter of the seismic survey data is able to follow the subsurface conditions from spread to spread.

As previously mentioned, it is the velocity of the sound wave through the subsurface materials that indicates the type of material encountered. However, the velocities in the same materials may differ from one section of the country to another, and from one season of the year to another. Wide experience is therefore necessary for the proper interpretation of the recordings from a seismic survey.

In general, in the northeastern part of the United States, the following

velocity table has been established for land exploration:*

1. Velocities from 1,500 ft. to 2,500 ft. per second usually denote dry, wind-blown sand, fine dry gravel, etc.
2. Velocities from 3,000 ft. to 4,000 ft. per second usually denote a heavier gravel with a small amount of clay binder. Normally, such gravel is dry.
3. Velocities from 4,500 ft. to 6,000 ft. per second represent either compact dry gravels with some clay binder, or gravels within the water table.
4. A velocity of 5,000 ft. per second represents a varved clay. This value is very constant.
5. Velocities from 6,000 ft. to a little over 9,000 ft. per second represent a hard pan or old till, which is heavy gravel and clay, some of which is cemented together by iron rust or oxidation.
6. Velocities from 10,000 ft. to 20,000 ft. per second indicate bedrock.

Under normal circumstances the lower velocities indicate a rock that is not so hard and, therefore, does not have so good bearing strength as a high-velocity one. Normally, the actual classification of the rock encountered is made by a study of the geological maps of the region being surveyed, supplemented by data obtained by the seismic method.

*"Seismology Applied to Shallow Zone Research" by Daniel Linehan, S.J., Symposium on Surface and Subsurface Reconnaissance, Special Technical Publication No. 122, Published by Am. Soc. Testing Materials.

Underwater Work

Seismic refraction surveys can be made under water as well as on land, and in much the same manner. The only problem that arises is the planting of the equipment in the subaqueous materials. If the underwater bottom material is a soft gaseous or aerated silt, the explosion wave may be entirely absorbed in that layer and never penetrate the harder materials below, almost regardless of how large a charge of dynamite is used. In such a case, it is necessary to plant the dynamite charge below the soft gaseous layer, in the firmer material below. Another problem may be encountered if the survey is being conducted in fast, shallow water. Then there will be difficulty in quieting the unrest of the instruments or preventing the breaking of the instruments or cable on the bottom.

Although underwater surveys may present greater problems and difficulties than land surveys, they have been successfully operated to locate bedrock for dams, bridges, and harbor facilities where, in many cases, it would have been impossible to obtain the bedrock profile by any other means.

Interesting Projects

Some of the more recent projects completed or under way by the Geophysical Survey Division of Gahagan Construction Corporation are summarized as follows:

Connecticut Expressway: In the fall of 1953 the Gahagan organization made a seismic survey of the then-proposed new Connecticut Expressway. This survey was made for Ammann & Whitney, consulting engineers, to help them in estimating the cost of construction. It covered almost the full length of the right-of-way wherever cuts were required, and enabled Ammann & Whitney to better estimate the amounts of loose till, hard pan, and bedrock to be excavated.

Mercer Power Site: Jackson & Moreland, engineers on the project, ordered a general survey of a proposed location of the Mercer Power Site for the New Jersey Power & Light Company This survey was to give a rock profile of the area and also to determine some of the physical characteristics of the overburden, such as its bearing strength and permeability. General results showed a 2-ft.-deep layer of top soil and silt, which was underlain by fine sands that would not be suitable for heavy foundations, but which would be easily excavated by a power shovel. The bedrock, which was on the aver-

REELING IN CABLE: Two members of the crew in the field reel in recording cable and carry some of the seismometers. The type of instrument spread is determined by the problem to be studied.

age 25 ft. below ground surface, was a hard rock with excellent bearing strength.

Sulphur Creek Dam Site, Washington State: A survey was made of the Sulphur Creek Dam Site, on the Upper Baker River in the State of Washington, for Stone & Webster Engineering Corporation, to determine the bedrock elevations at the site of the embankment that would adjoin the proposed dam. The survey showed that the area was covered by a top layer of loose sands and gravels, below which were strata of more compact sands and gravels within the water table, both of which could be excavated by power shovels without blasting. Along the 1,600-ft. line of proposed embankment, it was found that a depth to bedrock in excess of 300 ft. existed between outcrops which were apparent at either end of the proposed embankment.

Hudson River Bridge Sites: Another seismic survey was conducted for Ammann & Whitney, engineers, for the Port of New York Authority, on proposed bridge sites across the Hudson River, one at the Narrows from Brooklyn to Staten Island and another in the vicinity of 125th Street from Manhattan to New Jersey. The purpose of the surveys was to determine the depths to bedrock for the foundations for the proposed structures. This work was done in the water and out from the shore line about 1,000 ft. There was no accurate information available as to the depths to bedrock off shore because the rock was so deep. In the vicinity of 125th Street normal procedures would not work because the river bottom was covered by a deep layer of very gaseous silt, which absorbed the sound wave and prevented it from penetrating to the bedrock below. It was necessary, in this survey, to jet casing from 60 to 100 ft. through the silt layer before a firm layer of clay was reached, which would properly generate the sound wave.

Massachusetts Turnpike: The Massachusetts Turnpike Authority is making use of a seismic survey by Gahagan of the route of the new Massachusetts Turnpike from Weston, Massachusetts, to the New York State line. This seismic survey is being made for the nine different engineering firms that are designing the various sections of the turnpike. The information received will be used to determine route location as well as the quantities of various materials to be excavated. The coordinating engineering firm for the Massachusetts Turnpike Authority is Howard, Needles, Tammen & Bergendoff.

INSPECTING SEISMIC RECORDS: Engineers in the field inspect seismic records made by a high-speed camera. Wide experience is necessary for the proper interpretation of the recordings from a seismic survey on land or under water.

St. Lawrence Power Project: We were retained by Sanderson & Porter, engineers, to make a seismic survey in the swift waters of the St. Lawrence River at Massena, New York, at the site of the St. Lawrence Power Project. The purpose of this survey was to complete the bedrock profile in the river. The New York State Highway Department had made seismic surveys on land but had been unable to do the underwater work. Seismic investigations were conducted at the site of the proposed Long Sault Dam, the Barnhart Island Bridge, the coffer dams, and other locations to complete the bedrock profile for the project. These operations were unusually difficult and hazardous because they were carried out in the shallow and fast-running water of the St. Lawrence River, where currents in excess of 15 miles an hour were encountered.

Until recently, surveying subsurface conditions by the seismic method has not been readily available to engineers and construction companies. Now, however, the Geophysical Survey Division of Gahagan Construction Corporation, operating from headquarters in New York City, offers this service. Its chief of operations is Rev. Daniel Linehan, S.J., one of the world's foremost exponents of the seismic refraction method. For more than 12 years, Father Linehan has worked closely with engineers and contractors all over the United States on subsurface investigations using the seismic refraction method. The success of his activities is attested to by repeat orders received by the Gahagan organization.

STRIP MINING COAL AROUND A MOUNTAINSIDE

A summary of operations at Hampton Mines Stripping, 700 ft. above ground level near the town of Van, West Virginia

HENRY MINNIG*

IN 1948, Westmoreland Coal Company of Philadelphia contracted with Central Pennsylvania Quarry, Stripping and Construction Company of Hazleton, Pennsylvania, to strip mine bituminous coal at Hampton Mines in an undeveloped area of about 10,500 acres of land in southern West Virginia, in Boone County, near the town of Van. The coal seam is located 700 ft. above the base of a hillside.

*Superintendent, Central Pennsylvania Quarry, Stripping and Construction Company
Hazleton, Pennsylvania

A winding roadway, 3 miles long, had to be constructed up the rugged mountainous terrain to provide access to the area. The Chesapeake & Ohio Railroad built a 7-mile spur line from Clothier, West Virginia, to service the new mining activities. The operation

HAMPTON MINES' COAL: After blasting the coal at Hampton Mines Stripping, it is excavated with a Bucyrus-Erie 54-B shovel with a 2½-cu. yd. dipper and loaded into 15-cu. yd. Euclid trucks for transportation around the side of the mountain to the head house above the plant.

STRIPPING THE HIGHWALL: In stripping the highwall of rock covering the coal, 6-in.-diameter holes are drilled horizontally into the overburden to a depth of 54 to 72 ft., spaced on 11-ft. centers, using a McCarthy 103 Highwall drill.

LOADING DYNAMITE CHARGES: A four-man crew handles the details of loading the drill holes in the highwall with Hercules Dynamite. The explosives loading ratio averages 0.38 lb. of dynamite per one cu. yd. of overburden.

BLASTING RESULTS: This pile of broken rock is typical of the excellent fragmentation obtained from primary blasts in the variable overburden of sandstone, slate, and shale in the highwall at Hampton Mines Stripping.

DUMPING SPOIL MATERIAL: After the overburden has been blasted, a Lima 2400 stripping shovel with a 6½-cu. yd. dipper excavates and dumps the spoil material over the mountainside. This eliminates haulage and disposal problems.

known today as Hampton Mines Stripping, is averaging a production of 800 tons of strip coal a day. Westmoreland Coal operates deep mines in the area, which produce an average of 2,400 tons of coal a day.

In the beginning, the strip-mining operations were carried on in the Upper and the Lower Hampton Seams. These seams are separated by a shale formation varying in thickness from 18 to 30 ft. The coal in the upper seam is 6 to 7 ft. thick; in the lower seam, the coal is 5 to 6 ft. thick.

Overburden 80 ft. High

The first stripping was done in the top seam and approximately 40 ft. of overburden — a massive sandstone formation with mud seams — was excavated. After the stripped coal was loaded, a McCarthy 36-in. coal-auger drill was used to recover additional tonnage. Later, work in the top seam was abandoned and operations were transferred to the lower seam.

In places where the top seam had been stripped, the lower seam had an overburden cover of shale and slate from 18 to 30 ft. After both seams were stripped, the highwall of overburden material extended to a height of 80 ft. When shale comprised the overburden, the drilling and blasting details presented no unusual problems. Where a combination of slate and sandstone occurred, it was difficult to maintain normal stripping progress.

When sandstone was present in the floor, it was necessary to blast the coal preparatory to loading it because the coal adhered to the sandstone.

Drilling and Blasting

For primary blasting in the highwall, 6-in.-diameter holes, from 54 to 72 ft. deep on 11-ft. centers, are drilled horizontally with a McCarthy 103 Highwall drill. The depth of the holes is determined by the slope of the hillside. When it is steep, the shorter length holes are drilled. When it is not steep, the longer holes are utilized.

Various grades and strengths of dynamites are used for blasting in the overburden, depending on the material encountered. In the shale, experience has shown that a combination of Hercules® 40 per cent Extra Dynamite and Hercomite®-B produces excellent fragmentation with no secondary blasting required. When the overburden is shale and sandstone, equal amounts of Hercules 60 per cent Extra Dynamite and Hercomite-B are used, with the 60 per cent grade loaded into the back of each drill hole.

In the massive sandstone formation interspersed with mud seams, the explosives loaded are varied to fit existing situations. Experiments have been made using different grades and

COAL 5-FT. THICK: The tractor-marked floor of the pit between the highwall and the spoil bank at Hampton Mines Stripping is a block of Hampton seam solid coal 70 ft. wide, 500 long, and 5 ft. deep, ready for recovery.

strengths of dynamites, with the charges detonated by both regular electric blasting caps and short-period delay electric blasting caps. Much progress has been made in developing the most satisfactory explosives combinations to use to obtain desired results.

All of the dynamite grades used by Central Pennsylvania Quarry, Stripping and Construction Company at Hampton Mines Stripping are packed in 23G cartridges with tapered ends. The cartridge size for the two Extra grades is 5 in. by 25 lb. For Hercomite-B, the cartridge size is 5 in. by 20 lb. The explosives loading ratio for primary blasts is 0.38 lb. of dynamite per one cu. yd. of overburden in place.

BLASTING THE COAL: When coal in a pit has to be blasted, holes 5 ft. deep spaced on 8 by 8-ft. centers are drilled with the portable drill rig, and each hole is loaded with three cartridges of 40 per cent Extra Dynamite.

Priming and Stemming

The explosives charges loaded into the drill holes are primed with Hercules® Electric Blasting Caps with 60-ft. leg wires. The cap leg wires are covered with the usual plastic insulation and an extra covering of cotton-based material to make them especially durable. Some Hercules Short-Period Delay Electric Blasting Caps, ranging from the first delay period through the tenth, are also used. The latter type of detonator is employed when Primacord* is placed in the drill holes as the primer for the dynamite charges. In such instances, the short-period delay electric blasting caps are taped onto the end of the Primacord at the collar of each loaded hole.

After the loading and priming details are completed, the charged holes are tamped with 20 ft. of stemming. Drill cuttings packed into laminated asphalt bags, size 3¾ by 4 by 24 in., are used as the stemming material. About 15 bags are loaded into each hole, one bag at a time.

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

STRIP MINING SUPERINTENDENT: Henry Minnig is superintendent of strip-mining operations at Hampton Mines Stripping near Van, West Virginia, for Central Pennsylvania Quarry, Stripping and Construction Company.

AT THE HEAD HOUSE: After making the 1½-mile trip from the strip mine to the head house, a Euclid truck dumps a load of coal into one of the bins. Deliveries of strip mine coal to the head house average 800 tons a day.

THE BLENDING BINS: At the head house, strip mine coal is dumped into one bin and deep mine coal into the other three. The coal is blended in the proportion of ¼ strip mine and ¾ deep mine by speed changers on four feeders.

After blasts in the massive sandstone with mud seams, some large boulders are usually present in the banks of broken material, having been rolled out between the mud seams which dissipate the action of the explosives. For secondary blasting of the boulders, holes are drilled with a Le Roi Tractair portable drill, a combination 35-hp. tractor and a 105-c.f.m. air compressor, with a drill rig mounted on the rear. It is a very convenient drilling unit as it eliminates the carrying of jackhammers over a pile of irregular sizes of blasted material. The holes are loaded with 1¼ by 8-in. cartridges of 40 per cent Extra Dynamite.

As the coal seam is located high on a hillside, the blasted overburden is cast over the hill and no haulage is required A Lima 2400 stripping shovel with a 6½-cu. yd. dipper is used to excavate and dump the spoil material. A Caterpillar D-8 bulldozer is employed to assist in the disposal operations.

Loading the Coal

After the stripping of the overburden is completed, the coal is cleaned by scraping it with a Caterpillar road grader and sweeping it with a broom attachment on the Tractair portable drill rig. If necessary, it is blasted with small charges of 40 per cent Extra Dynamite before being loaded out. Several thousand tons of coal are kept ready for loading so that normal operations can continue if, for any reason, the stripping shovel should be temporarily inactive.

The strip coal is loaded out with a Bucyrus-Erie 54-B shovel equipped with a 2½-cu. yd. dipper into 15-cu. yd. Euclid trucks. The Euclids transport the coal around the side of the mountain to blending bins at the preparation plant. An average of 800 tons of strip coal is transported to the plant each day. At present, the loading point in the strip pit is 1½ miles from the preparation plant. A roadway is constructed on top of the spoil bank with the D-8 bulldozer and maintained with the road grader. It is kept in excellent condition so that the trucks can make the round trip with speed and safety.

The production from both the Hampton Mines Stripping and the Westmoreland deep mines is delivered to four bins in the head house, one bin receiving the strip coal and the other three bins, the deep-mine coal. All of the coal is blended in the proportion of 25 per cent strip coal and 75 per cent deep-mine coal. The blending is accomplished through the medium of speed changers on four feeders, which are under the direct control of an operator stationed at the top of the bins.

The operations of Central Pennsylvania Quarry, Stripping and Construction Company are directed by W. C. Morris Butler, president; W. C. M. Butler, Jr., vice president and general manager; C. T. Butler, executive vice president; and L. L. Butler, secretary and treasurer. Henry Minnig is superintendent of Hampton Mines Stripping.

MODERN ROADWAY: A roadway is constructed on top of the spoil bank with a D-8 bulldozer and a road grader. It is maintained in excellent condition to expedite truck travel between the strip mine and the head house.

Thomas J. Walsh

Carl B. Jansen

THE MOLES AWARDS FOR 1955

Plaques and citations to be awarded Thomas J. Walsh and Carl B. Jansen for outstanding contributions to construction progress

WHEN members and guests of The Moles, a New York association of tunnel builders and heavy-construction men, convene in the Waldorf-Astoria Hotel, New York City, on February 2 for the annual dinner-ceremony of the association, the 1955 awards for outstanding achievements in the construction industry will be presented to Thomas J. Walsh, a member, and to Carl B. Jansen, a nonmember.

Thomas J. Walsh

Thomas J. Walsh, member recipient, is chairman of the board of directors of Walsh Construction Company, New York City. The award to Mr. Walsh crowns a long record of achievement in the construction industry, dating back to 1907. In that year he joined the company founded by his father, after having finished the baseball season as a catcher with the Chicago Cubs. Mr. Walsh is a graduate of St. Mary's College in Kansas.

Before his election as board chairman, Mr. Walsh was president of Walsh Construction Company from 1916 to 1946. World famous in the field of railroad construction, the company has driven more tunnels than any similar organization in the world. It was one of a group of firms that built the first Grand Coulee dam; it was one of four companies that erected the United Nations secretariat building; it helped in the construction of air bases in France for the U. S. Army Air Corps; and, at present, it is busy building air bases in Spain.

Carl B. Jansen

Carl B. Jansen, nonmember recipient, is president of Dravo Corporation, Pittsburgh, Pennsylvania. The award to Mr. Jansen culminates a series of successful accomplishments during the past 32 years. He became associated with the Dravo Corporation immediately following his graduation from Union College in Schenectady in 1922. During the intervening years, he has held the following positions with the Dravo organization: field engineer, construction superintendent, general superintendent, assistant to the president, manager, general manager, and president since 1946.

Some of the many large projects on which Mr. Jansen directed operations for Dravo include the East Bay crossing of the San Francisco Bay Bridge, subways in Philadelphia, and a section of the Delaware River Aqueduct. During World War II, the Dravo Corporation built twin shipways at Newport News, Virginia, where some of the world's largest aircraft carriers were built for war service with the United States military forces.

THE URAVAN PLANT: The large uranium ore-treatment mill of United States Vanadium Company at Uravan overlooks a part of the San Miguel River Valley in Colorado.

MINING URANIUM
IN THE COLORADO PLATEAU

Activities in a 65,000-square mile area rival the fabulous California gold-rush days

CHARLES F. THOMAS*

PART II

ANOTHER incentive provided under the Act is the payment of a development allowance of 50 cents a lb. for ores assaying 0.10 per cent or more uranium. This was done because of expenditures necessary for maintaining and increasing the developed reserves of ore. Operators who accept this allowance must agree to spend such funds for the further development or exploration of their properties. A haulage allowance of 6 cents a ton-mile for transportation of ore purchased under the latter amendment is also made for hauls up to 100 miles.

*P. O. Box 1017
Ephrata, Washington

An additional premium of 75 cents a pound is paid for each pound of uranium in excess of 4 lb. per short ton. A premium of 25 cents a pound is paid for each pound in excess of 10 lb. of uranium per short ton.

An initial production bonus will also be paid by the Commission on the first 10,000 lb. of acceptable uranium-bearing ores delivered to mills or to Commission ore-buying stations from new mining properties. These bonus payments per pound of uranium oxide range from $1.50 for ores assaying 0.10 per cent U_3O_8 to $3.50 for ores assaying 0.20 per cent U_3O_8. The payments amount to a maximum bonus of $15,000 to $35,000, depending on the grade of ore delivered. The purpose of the bonus payments is to encourage and to assist the development of new sources of domestic uranium production and to provide an incentive for the delivery of higher grade ore. The AEC has announced that up to April 16, 1954, initial production bonuses totaling more than $3,263,000 had been paid.

Grand Junction, Colorado

The location of the operations office of the Atomic Energy Commission at Grand Junction, Colorado, is both economical and strategic. Within a few hours, any point in the region may be

reached by automobile. Few of the roads permit travel speeds of more than 35 miles an hour. Five service divisions of the Commission are located at Grand Junction, namely, Construction and Supply, Finance, Legal, Security, and Personnel. Also, three operating divisions, Exploration, Mining, and Processing, have their headquarters at this location. The United States Geological Survey maintains offices within the Compound, as the headquarters area is known. Four contractors, American Smelting and Refining Company, National Lead Company, Walker-Lybarger Construction Company, and Galigher Company, operate from the Grand Junction headquarters of AEC. Approximately 1,200 employes are now working there for the AEC, the USGS, and various contractors.

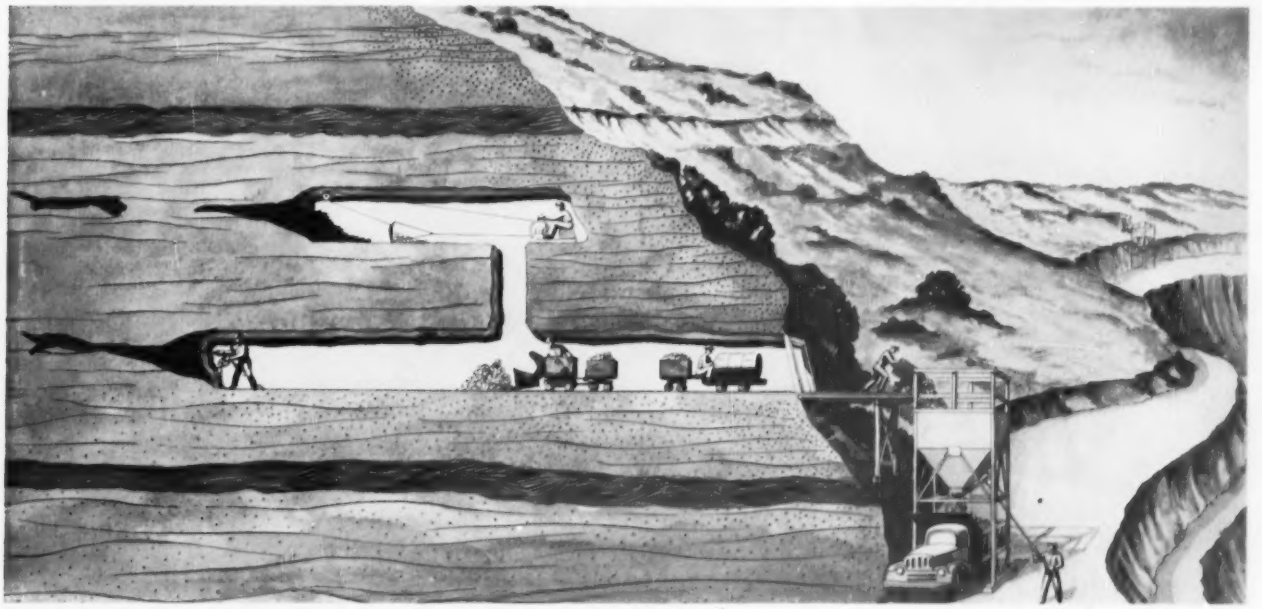
In 1939, the U. S. Geological Survey began to make careful studies of the carnotite deposits. Investigations were continued as a strategic minerals project through 1945, aided by the State of Colorado and the Colorado Metals Mining Fund. Since 1947, in conjunction with the AEC, the USGS has continued its extensive study of the deposits. As late as 1952, it was not realized that uranium was largely present in other measures in the geologic "stack." In 1947, the Geological Survey commenced a large-scale program of diamond-drill exploration in the Morrison formation in the Uravan mineral belt. Most of the earlier mining work in the region had occurred at the outcrop of the measures along the winding cliffs and canyons. A limited amount of exploratory drilling had been done by a few claim owners, as an aid to more economical development. However, the USGS widened the scope of its work by moving back to the higher ridges between the outcrops. While the drilling by private operators was generally to shallow depths, the Geological Survey drilled to greater depths in order to properly explore the formations. Drilling averaged 135 to 140 ft. in depth. It developed that in the Morrison formation, with its lenticular deposits, the measure varied from 20 ft. to more than 80 ft. thick.

Drilling

From early 1948 through the calendar year 1953, the total footage drilled in the Colorado Plateau by the Atomic Energy Commission and the Geological Survey exceeded 3½ million ft. Through the same period, private firms drilled an additional 3½ million ft., making a grand total of 7 million ft. It is estimated that the Government agencies have drilled more than 1 million linear ft. during the fiscal year ending June 30, 1954. At present, private firms are now drilling much greater footage than the Government forces, with expenditures amounting to about two-thirds of the total cost of the exploratory drilling.

Most of the drilling by the Government agencies has been done with diamond drills. The field activities of the private firms include many 4½-in. rotary drills, diamond drills, and 36-in. calyx drills. A few churn drills and several percussion-type drills are also in operation. The cuttings from most of the dry-type drilling are recovered for testing with a Geiger counter or other equipment. With the diamond drill, the core from the measure provides an excellent sample, which may be readily tested. Sensitive testing equipment has also been designed, which may be lowered into holes 500 ft. or more in depth and reactions determined wherever they occur. It is estimated that there are more than 175 drilling contractors in the field. In December, 1953, the AEC reported 100 diamond-drill rigs, 30 rotary rigs, and 8 percussion rigs available for contract work. Since then, the number has been increased.

The rate of drilling varies with the type of rig used. Diamond-drill rigs are reported to average 70 ft. or more a day. The rotary rigs, reported to be performing about 30 per cent of the



TYPICAL URANIUM MINE: Shown here is a cross section of a typical uranium mine showing the ore bodies in black and several mining procedures. About 200 small mines like this are scattered throughout the area.

drilling done in the area, produce an average of 500 ft. a day.

Blasting

As is customary in most mining and quarrying operations, the drilling and blasting of ore and rock in the uranium fields of the Colorado Plateau are adapted to the ground conditions encountered. A few of the smaller operators use the old-fashioned method of drilling with handsteel and a "single-jack," or a 4-lb. hammer. Most of the small producing outfits use jackhammers. Detachable bits, with their longer life and ease of handling, are replacing the older hand- or machine-sharpened drill steel.

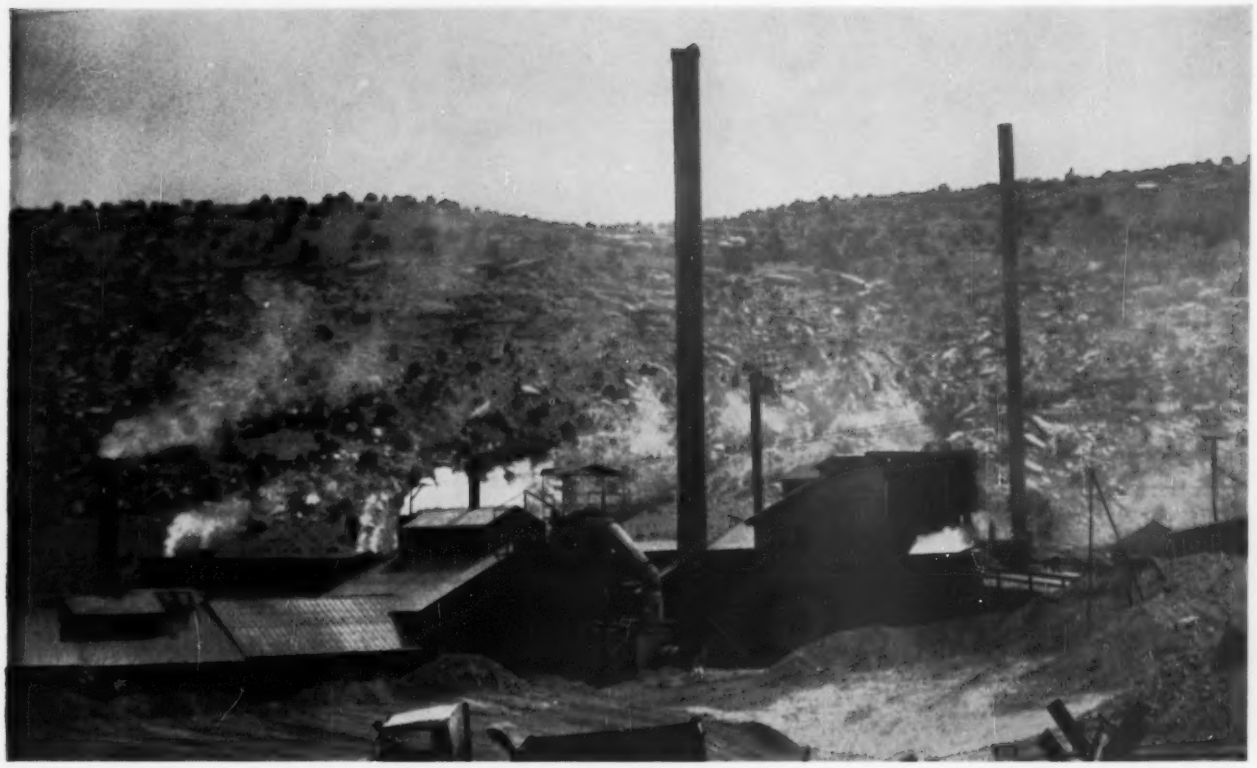
The majority of the mines throughout the uranium field are now equipped with one or more standard portable compressors. Their capacities vary from 60 to 600 c.f.m., depending on the amount of drilling required each day. Outfits commencing operations usually rent their equipment from machinery-supply dealers in Grand Junction, Salt Lake City, or Denver. Practically every type of equipment required can be furnished, with the rental charges applying on the purchase prices if so desired.

Small compressors supplying air for a single jackhammer can be hooked behind a light pickup truck or an automobile and moved from claim to claim. Where mining is permanently developed, pipe lines varying in size from 1½ to 3 in. in diameter, convey air close to the working faces where hose connections complete the installations to the drills.

DRILLING A BLAST HOLE: A miner with a rock drill mounted on a jackleg drills a hole into the ore preparatory to firing a blast in one of U. S. Vanadium Company's mines.

DIAMOND DRILLING: An outfit from Texas at work diamond drilling a hole into the Chinle formation, estimated to be 600 ft. below the surface.

NAVAJO INDIANS: Navajo Indian miners at the site of Monument No. 2 operations of Vanadium Corporation of America in northeastern Arizona. The Navajos have proved to be steady, reliable workmen.



THE NATURITA MILL: This is the mill of Vanadium Corporation of America located 3 miles from Naturita, Colorado, on the San Miguel River.

A few drill holes, strategically placed in the soft carnotite formations, will break a maximum of ore with a minimum of dynamite. Miners become adept in gauging the amount of explosives to use in a blast to avoid throwing or scattering the ore. In most workings, it is unusual to drill a round of more than five holes, each 5 ft. deep. The holes often break 20 to 30 tons of ore. Because of the unstable nature of the formations overlying the carnotite, much timbering is required to support rock slabs loosened by light blasting. Usually, a 25% strength ammonia-type dynamite is used, with some 40% strength grades used in the denser formations encountered.

In drilling and blasting sandstone, closer spotting of drill holes is required to obtain the smaller sized fragmentation required by the mills.

Both wagon drills and jackhammers are used in the few stripping operations thus far undertaken. As with coal and other minerals, stripping is not economical where the overburden is too deep or heavy, or hauls of the waste materials excessive. Vanadium Corporation of America at Monument No. 2 mine in northeastern Arizona, and Anaconda Copper Company at Grants, New Mexico, have been engaged for many months in heavy stripping programs. Uniform programs of drilling and blasting are closely followed. No springing of holes is undertaken since most of the measures are broken without unusual difficulties. No vertical fractures or seams occur to impede the economical drilling of the measures.

In many of the smaller mines safety fuse attached to blasting caps is used for firing rounds. In the larger mining operations, electric delay detonators are in general use. In conformance with state mining laws governing the use of explosives, permissible powders are used in many underground operations.

Government Leases

Much of the land in which the carnotite deposits are found is public domain. As the exploration work progressed and the value of the measures was determined, certain public lands were withdrawn from entry. To date, a total of 430,000 acres has been withdrawn. This was done to prevent wholesale exploitation and profiteering where the deposits were proved at Government expense. In its place, the Government has set up a leasing program, whereby responsible individuals or organizations mine the ore under most of the same benefits as on privately owned land.

AEC mining leases are desirable because the closely spaced drilling in the exploratory work defines the ore limits and the thickness of the deposits. All drilling information relative to the extent of the deposits is available for the lease applicants when selected for a mining lease. From a current list of more than 300 applicants for leases, those best qualified are first offered the opportunity to mine the ground. Qualifications are established on abilities to finance, manage, and mine the ores on the claims available for lease. Certain minimum qualifications are required of every lease applicant. He must be an American citizen at least 21 years of age, and have had at least three years' uranium-mining experience, or five years of general mining experience, of which he must have been in charge of operations for two years.

Many conflicts in titles have occurred where mining claims have been filed on land previously covered by oil leases. The AEC has lent every aid

THE UTEX MINE CAMP: A bird's-eye view of the camp at Utex mine. The shaft headframe is at lower left, the slope adit is at the left of the headframe, and the stock pile is down in the canyon.

possible to clarify these situations. Recent legislation passed by Congress permits multiple use of such lands by two different claim or lease holders. Several hundred wells have been drilled over the area in a search for oil. Undoubtedly, many wells have been drilled through existing strata of radioactive ores which would have been much more valuable than the gases tapped in the measures.

Where minerals are discovered on land within the Navajo Reservation, all leasing is handled through an office established at Windowrock, Arizona. A leasing fee of 15 per cent of the value of ores mined within the area is returnable to the Department of Indian Affairs to be expended on schools, roads, and other benefits. Many large deposits of uranium have been found within the reservation. Mining companies are required to use mostly Indian labor. The Indians make good miners and the effect of the high wages they are receiving for their work is reflected in the modern automobiles and pickups many are driving.

Buying and Shipping Stations

At strategic points over the four states, buying and shipping stations are located on rail lines or highways. Producers haul their ore to these points in trucks, where it is sampled and loaded into railroad cars for shipment, or for delivery to the several mills now processing uranium. One hundred per cent of the ore mined in the region is produced and delivered to receiving stations by private industry.

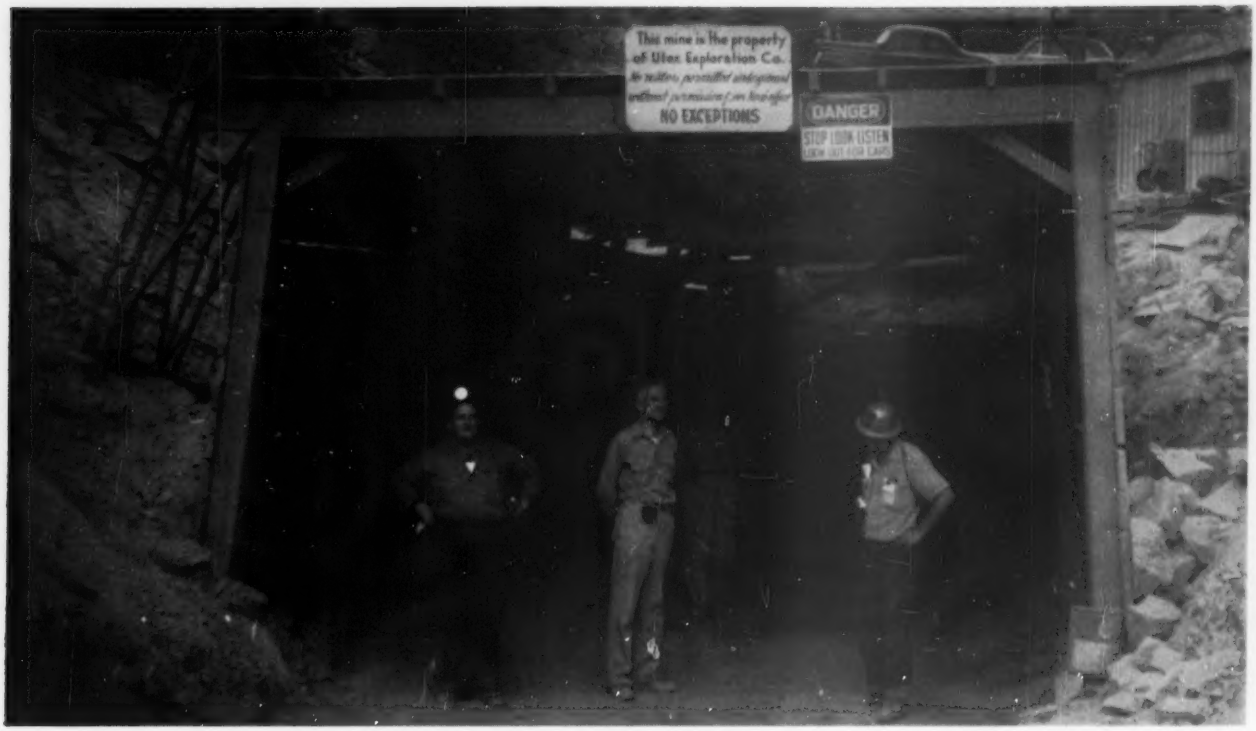
With the exception of the uranium-processing plant at Monticello, Utah, all plants or mills are privately owned and operated. At Durango and at Naturita, Colorado, mills are owned by Vanadium Corporation of America. At Rifle and Uravan, Colorado, plants are owned by United States Vanadium Company. A plant at Grand Junction, Colorado, is owned and operated by Climax Uranium Co. At Salt Lake City, the Vitro Uranium Company operates a mill. The Government-owned mill at Monticello is operated by the Galigher Company under a contract with the AEC. Anaconda Copper Company operates a newly completed mill at Grants, New Mexico. The Kerr-McGee Oil Industries are constructing a mill at Shiprock, New Mexico, and another new mill is to be started soon at Moab, Utah. All uranium concentrates produced in the western part of the United States are purchased by the Grand Junction operations office of the AEC.

To assist industry in finding processes for extraction of uranium, the Atomic Energy Commission operates pilot plant facilities. These are small-scale mills where actual test work can be performed and results observed by those studying the processes. The pilot plant at Grand Junction is operated by the National Lead Company.

Health and Safety

Since 1950, the United States Public Health Service has been conducting physical examinations, at regular periods, of the men employed in the uranium-mining industry. The program ties in with the health and safety work of the different states, including studies of conditions which might affect the health of workmen in the industry. Miners leaving their occupations or moving out of the area are urged by the Service to keep the Department advised of their whereabouts in order that succeeding long-range checks may be made through the years.

While each of the four states in



SLOPE PORTAL: A 12-degree slope extends 400 ft. to the workings of Charles Steen's fabulous Utex mine 40 miles southeast of Moab, Utah, on the Colorado River. The mine's location is near the center of a group of 12 claims he located early in 1951.

which the uranium mining is now being done has its own safety divisions and state inspectors to check on the conditions in the mines, the AEC follows through with experienced engineers who also watch the rapidly developing industry. No controls are exercised, since these powers come from within the individual states. The Bureau of Mines assists with instructions in safety and first-aid training.

Charles Steen

Charles Steen, his "Mi Vida" strike, and some of the good fortune that has followed him have been much publicized. He is a quiet, unassuming young man, a graduate geologist of the Texas School of Mines. Many stories are told of his generosity to those who befriended or assisted him. No story about uranium mining would be complete without a description of Steen's Utex mine, which lies 40 miles southeast of Moab, Utah, on the Colorado River.

Moab is an old Mormon town in southeastern Utah. The pioneers who moved into this desolate, yet strangely beautiful, canyon country settled there on orders from Brigham Young. The little valley surrounding the town is walled in by colorful red cliffs of massive sandstone. At innumerable places in surrounding canyons are high natural bridges and tall rock spires.

The canyon where the Utex mine and surrounding claims are located is rough and rugged. The mine, named from a combination of the names of Steen's two lucky states, Utah and his birth state of Texas, is situated near the center of a group of 12 claims he located in early 1951.

After constructing a roadway 4 miles long from the nearest county road, Steen moved a diamond-drill rig into the lonely canyon in July, 1952. Three days later he cored into a high-grade vein of ore in the Chinle formation at a depth of 70 ft. His sudden rise to wealth is as fabulous as any story of the gold-rush days.

Grubstake of $15,000

To finance his prospecting, Steen obtained a grubstake of $15,000 from his mother, Mrs. Roselie Shumaker, now the treasurer of Utex Exploration Company, an organization formed by Steen after the discovery of uranium ore on his claims. His ideas had been ridiculed and criticized by many geolo-

MINED ORE: A Koehring Dumptor loaded with uraninite is driven up the slope from the Utex mine to dump the ore outside onto the stock pile.

AT THE STOCK PILE: At the stock pile, a Caterpillar HT-4 loader excavates and dumps uranium ore from the Utex mine into trucks for transportation to buying stations at Moab, 41 miles away, and Brindell, Utah, 78 miles distant.

gists who were more familiar with the country and its structures than he. Even though for a time Steen was about ready to give up, he stuck stubbornly to his plan of exploration and proved that uranium existed in the stratum in paying quantities. He sunk his shaft on the evidence of the core from one drill hole. He did not have enough drill pipe to core other holes in the ore zone after drilling the first one.

The Steen claims are in the Big Indian Mining District where the formations range from Upper Pennsylvanian to Upper Cretaceous. The ore is principally uraninite, associated with smaller amounts of tyuyamunite, a calcium-uranium vanadate. Ores sampled and assayed show a wide variance of values ranging from 0.10 per cent to 87 per cent uranium.

The sinking of an 8 by 8-ft. shaft to the ore body began in October, 1952. The first ore from the blanket vein was hoisted on December 4, and regular shipments were made two days later. The shaft operations soon proved the need for additional facilities to speed up the ore handling. An adit 10 by 10 ft., inclined downward about 12 degrees, was begun 400 ft. southeast of the shaft. With the completion of this slope, production was increased.

STEEN CANYON ROAD: A truck loaded with uranium ore from the Utex mine rolls down the road in Steen Canyon en route to a buying station.

Room-and-Pillar Mining

At present, the mine is being developed on a modified room-and-pillar method with all development work occurring in the ore measure, which runs from 10 to 40 ft. in thickness. Although roomnecks are turned each 100 ft., no rooms or stopes have been opened. The drift headings are about 12 by 16 ft. in cross section. To assist in developing satisfactory fragmentation (all ore delivered to the mills is required to be less than 12 in. in diameter), 50 to 110 holes are drilled for the blasting

rounds, the number of holes drilled conforming with the size of the headings. The holes are drilled 6 ft. deep and break about 60 tons of ore. Drill steel of Swedish manufacture equipped with tungsten carbide and chisel bits is used in drilling. A drill jumbo with two machines mounted on a diesel tractor speeds the drilling operation. Compressed air for the operation of the drills is supplied to the various headings through 2- and 4-in. pipe lines carried into the mine through 24-in. drill holes. The compressed air is developed with two Ingersoll-Rand Gyro-Flo 600-cu. ft. rotary compressors.

All ground is supported with 1 in. by 6-ft. roof bolts anchored at 4-ft. intervals. No timbers are used in the mine. The ground is generally firm but with occasional slabs which are loosened by blasting or air slacking. Wooden blocks 3 by 10 by 18 in. used with 8 by 8-in. steel washer plates are advantageous in tightening the washers to the ground to be supported. Two miners are employed to place the roof bolts.

Ore is loaded into two 7-cu. yd. Koehring Dumptors with an International TD-9 tractor Lodover and a Caterpillar six-shovel loader. All diesel-operated equipment in the mine is fitted with water scrubbers on the exhausts. Electricity is generated for use at the mine and the adjacent camp with diesel-driven generators, one 60 KW and one 100 KW.

No Water in the Canyon

No water or springs occur in the canyon, and water is hauled from the town of Moab in a 1,200-gal. tank truck and emptied into a 5,000-gal. storage tank erected on the hillside above the mine and camp. All drilling in the mine is wet-drilling. Water consumption totals about 2,000 gals. a day.

Ore hauled from the mine is dumped onto outside stock piles and reloaded onto trucks with a Caterpillar HT-4 loader. The trucks transport the ore to buying stations at Moab, 41 miles away; to Brindell, Utah, 78 miles distant, with rail haul to Vitro Chemical Company at Salt Lake City. The uranium ore mined has averaged about 0.59 per cent. The value of production as of July 30 was in excess of $5,000,000.

Mine ventilation is developed by both natural and artificial means. Air is forced into the headings through an 18-in. Bemis vent tube extending down the shaft from a Coppus Ventair TP-9 blower driven by an electric motor. After the vent pipe reaches the mine level it is extended to the working headings. Canvas vent tubing is used where it is considered necessary to provide further mine ventilation.

The Utex mine has no labor problems. Premium wages well above the scale for similar work are paid by the company, and no deductions are made for board and lodging furnished to the men at the mine camp.

The safety standards of the company require the use of electric lamps, hard hats, and safety shoes. Employes are instructed by Bureau of Mines' representatives in safety practices and in first-aid work. Two shifts of 24 men each are employed at the mine.

The officials of Utex Exploration Company are Charles A. Steen, president and chief geologist, Moab, Utah; W. T. Hudson, vice president, Los Angeles, California; Roselie Shumaker, treasurer, Moab, Utah; Mrs. Maxine Boyd, assistant treasurer, Moab, Utah; and Mitchell Melich, secretary, Moab.

(To be continued)

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HAROLD H. WHITE

CONSULTING ENGINEER
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MULTI-STATE PROFESSIONAL REGISTRATION · 30 YEARS' EXPERIENCE IN ANALYSIS OF EXPLOSIVES EFFECTS · INTERNATIONAL BACKGROUND

IN QUARRYING explosives research pays off

Good fragmentation and a low bank of broken stone—here's a typical example of how explosives research pays off. In quarrying, the proper selection and efficient use of industrial explosives minimize the need for secondary blasting, speed shovel production, and contribute to an overall economical operation.

Hercules is a pioneer in the manufacture of explosives, detonators, and in the development of modern blasting methods. Hercules' extensive service facilities are at your disposal for solving blasting problems, not only in quarrying, but for mining, on construction jobs, and in exploring for petroleum—in fact, wherever explosives are used.

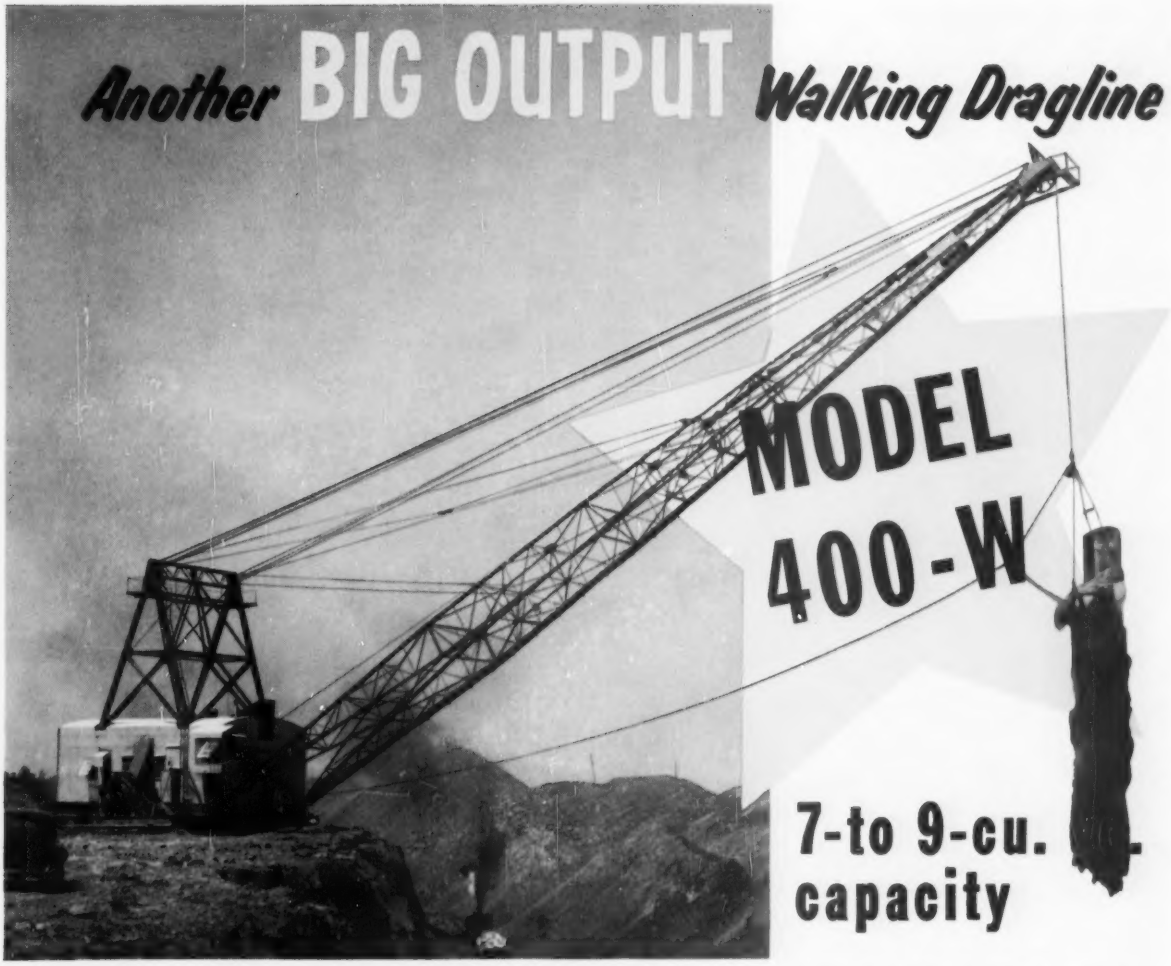
HERCULES POWDER COMPANY
INCORPORATED

Explosives Department, 990 King Street, Wilmington 99, Del.

Birmingham, Ala.; Chicago, Ill.; Duluth, Minn.; Hazleton, Pa.; Joplin, Mo.; Los Angeles, Calif.; New York, N. Y.; Pittsburgh, Pa.; Salt Lake City, Utah; San Francisco, Calif.

XR54-8

Another BIG OUTPUT Walking Dragline



Here's big news for men engaged in strip mining or heavy-duty construction work — Bucyrus-Erie has added another big-yardage, all-weather dragline to its world-famed "walker" line. You'll find unequalled money-making features in the new 400-W . . . here are some of them.

THREE POWER COMBINATIONS — Your choice of heavy-duty diesel engine, electric power with independent motor-driven drums, and electric power with clutch-operated drums.

EFFICIENT FRONT END — All-welded boom has T-section chord members with tubular bracing for maximum strength, minimum deadweight. Fast filling, clean carrying, quick dumping buckets help assure big output.

LONG WORKING RANGE — Without throwing bucket, material can be moved 405 feet with the 400-W's 200-ft. boom and 7-yd. bucket, 377 feet with the 185-ft. boom and 8-yd. bucket, and 351 feet with the 170-ft. boom and 9-yd. bucket. Digging depths range up to 135 feet.

RAPID OPERATING CYCLE — Fast hoisting and lowering with powerful air-controlled clutches and brakes . . . rapid acceleration and deceleration of the swing under variable-voltage Ward Leonard control.

EXCEPTIONAL MANEUVERING ABILITY — With exclusive Bucyrus-Erie walking mechanism, the 400-W walks where you want it, when you want it, in good weather or bad, even on ground that's too soft for other machines.

STRONG RIGID BASE — Provides 748 sq. ft. of bearing area for full stability in working and walking.

STURDY MAIN MACHINERY — Is simple in design . . . is arranged for accessibility in servicing and maintenance, and for maximum counterbalancing effect . . . is rigidly held in accurate alignment on deep-section revolving frame.

Complete information is yours for the asking — write today!

25L54C

BUCYRUS ERIE

South Milwaukee, Wisconsin

That's right mister! YOU'RE POINTING TO GREATER EFFICIENCY

When you point to that CP Airleg combination, Mister, why not point out that they team up to give the maximum drilling efficiency obtained when using Tungsten-Carbide bits. And that the leg takes constant recoil shock yet holds the drill firmly to the work. And while you're at it, point to the exclusive pressure release type control handle and balanced feed leg that assure steady bit pressure even under variable line pressure and different rock formations – eliminate "slapping" and reduce bit breakage. Then point to the emergency push button that releases feed-leg pressure instantly. Point out that it's available with a feed cylinder of either steel or aluminum alloy and with 36″ and 48″ feed travel. And that it makes a perfect combination . . . the Chicago Pneumatic Airleg and Sinker Drill! And if your friend has any more questions, Mister, ask him to write *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, New York.*

Chicago Pneumatic

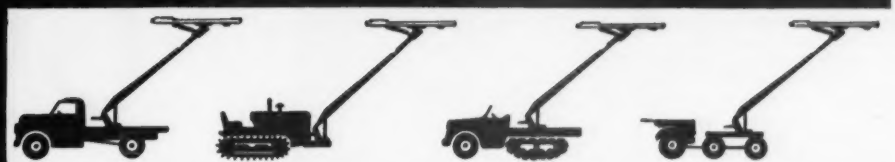
PNEUMATIC TOOLS • AIR COMPRESSORS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS • VACUUM PUMPS • AVIATION ACCESSORIES

GARDNER-DENVER

POWER SWING JUMBOS and REMOTE CONTROLLED DRILLS

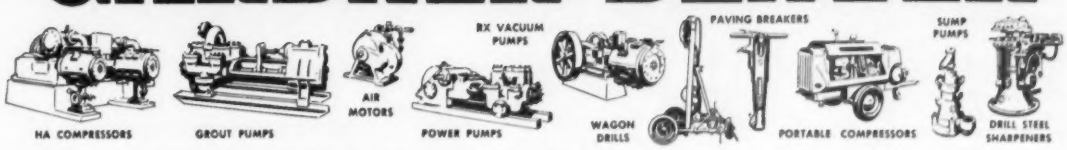
for mounting on your own equipment...

All positioning and drilling operations hydraulically operated and remotely controlled from driller's station. All positioning hydraulically locked. Write for information.



SINCE 1859

GARDNER-DENVER



THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

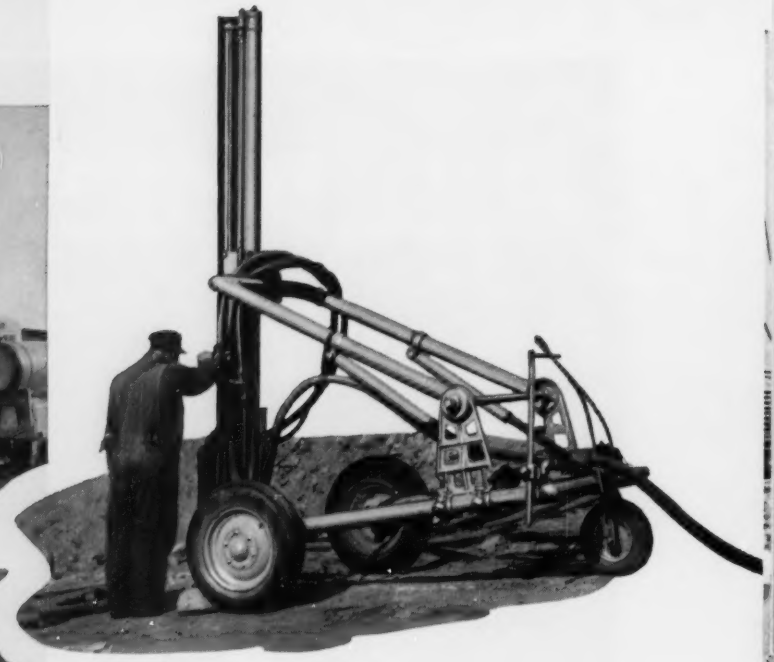
Gardner-Denver Co. (Canada), Ltd., Toronto, Ont.;
Montreal, Que.; Kirkland Lake, Ont.; Vancouver, B.C.; Nelson, B.C.; Winnipeg, Man.; Sydney, N.S.; Edmonton, Alta.

Le Roi-CLEVELAND T-286 Self-propelled Dual Drill Rig — consists of two patented Le Roi-CLEVELAND air feeds and drills with air-motor booms mounted on a mobile 25-hp tractor. You can drive the T-286 anywhere and tow your Airmaster compressor as well. You get quicker setups, faster drilling, better fragmentation, and lower costs.

Le Roi-CLEVELAND Clay Digger — at work on a sewer job. Well-balanced for easy handling, these spaders pack plenty of wallop for the stiffest clay. Operators like them, because they can do more work with less effort. A one-piece, bonded, rubber buffer with split steel collars keeps out dirt and grit — makes steel changing faster.

Le Roi-CLEVELAND Paving Breakers—are packed with power to make quick work of breaking up the hardest concrete. Sizes range from 18 to 80 lbs. Protective cushion in front end assures long life. Exclusive valving provides an easy-holding action that operators like. All these features help you reduce your costs.

Le Roi-CLEVELAND Backfill Tamper—weighs only 34 lbs. Thanks to its smooth-holding qualities it can be "walked" over the fill easily. Operators can do more tamping. The major parts are made from durable drop-forgings and a built-in oil reservoir keeps wear to a minimum. Just another example of how Le Roi gives you more for your money.



Your air-power operations

Cost Less

LE ROI GIVES YOU MORE FOR YOUR MONEY!

More air power!
More footage!
More profits!

This Le Roi-CLEVELAND DR-30 wagon drill for deep-hole work is powered by a Le Roi 600-cfm Airmaster mounted on skids. Two- and four-wheel mountings are also available in most sizes. Capacities: 85 cfm, 105 cfm, 125 cfm, 185 cfm, 210 cfm, 250 cfm, 365 cfm, 600 cfm; gas and diesel.

...with Le Roi Airmaster Compressors and Le Roi-CLEVELAND Air Tools on the job

AIR POWER is so widely used, because it does so many things — because it saves money

And money-saving air power costs less, when you use Le Roi Airmaster Compressors. Here's why:

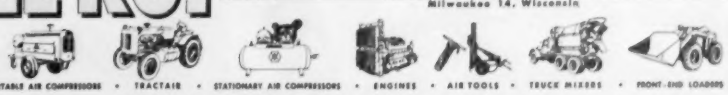
- Le Roi, with 8 sizes and 14 models, offers the widest range of portable-compressor sizes available. Now you can match your job requirements exactly, with an Airmaster Compressor that lets you do the most work for the least cost.
- Le Roi Airmasters are powered by a heavy-duty Le Roi engine designed especially for compressor service. Conservative engine ratings give you ample power reserve — for lower fuel consumption, less maintenance, lower operating costs. Magneto ignition gives you quick, easy starting — saves time, lets you get going faster.

For still better results, still lower costs, use Le Roi-CLEVELAND air tools with your Airmasters. They will drill more rock, dig more clay, break more pavement, tamp more fill for you.

Use this team and you will find, as so many have, that Le Roi gives you more for your money — more air power, more footage, more profits. See your Le Roi distributor or write us for further information.

LE ROI *Division of Westinghouse Air Brake Co.*

Milwaukee 14, Wisconsin



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C-152

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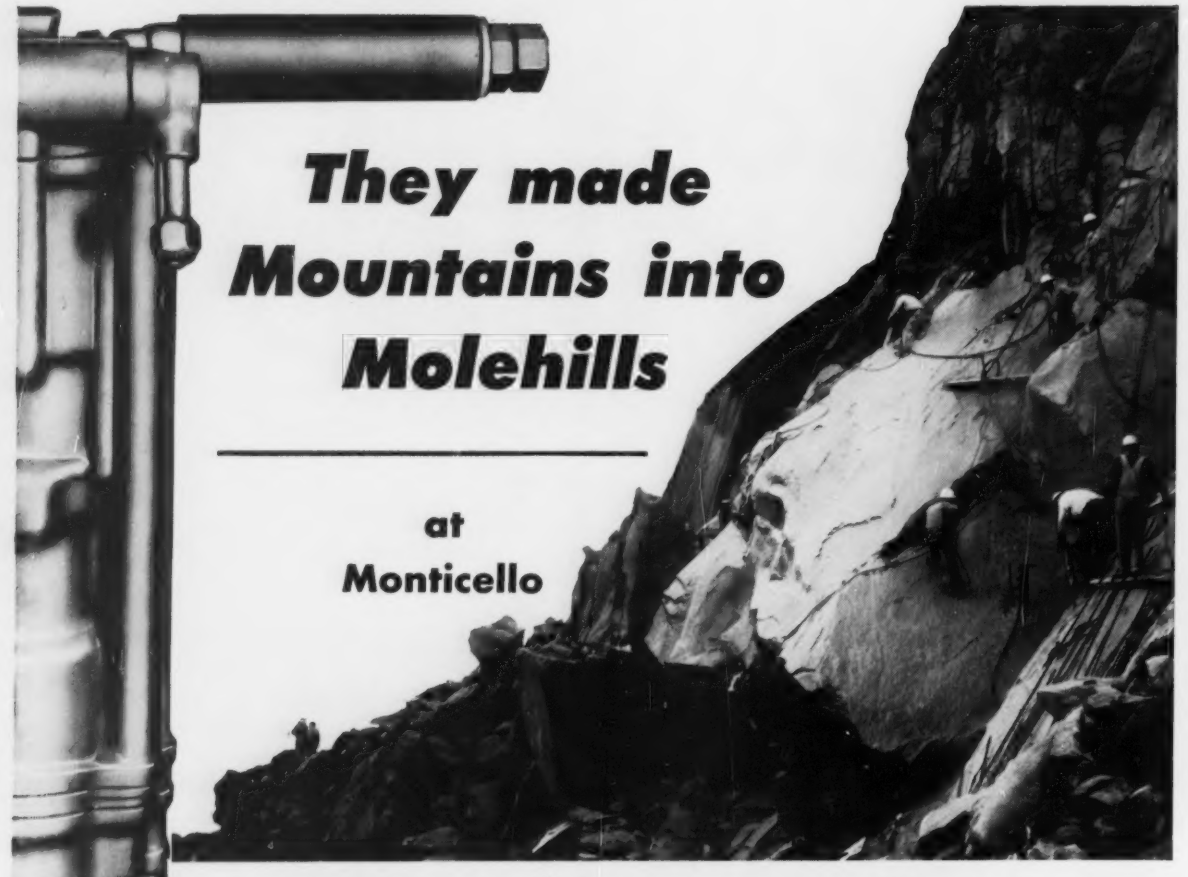

They made Mountains into Molehills

at Monticello

with JOY SILVER STREAK* ROCK DRILLS

Stout ropes on men and equipment prevented plunges down the sheer rock cliffs to the river 600' below.

Joy Rock Drills helped to carve a 3.5 mile mountain highway out of solid rock at California's Monticello Dam. Cuts up to 250 ft. were gouged from sheer cliffs.

The Joy drills proved dependable and easy to handle. Their patented Dual Valves permitted more performance per weight than comparable drills. Cadmium plating, inside and out, aided lubrication and prevented piston scoring, rusting and corrosion.

For full details on Joy Rock Drills, write for free Bulletin 87-X to ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

*SILVER-LIKE COVERING OF CADMIUM PLATING

Consult a Joy Engineer

FOR AIR COMPRESSORS • ROCK DRILLS • WAGON DRILLS • CORE DRILLS • BLAST HOLE DRILLS PORTABLE HOISTS • FANS • BLOWERS TUNNEL, QUARRY, MINE EQUIPMENT

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JOY

CONSTRUCTION EQUIPMENT MANUFACTURERS FOR OVER HALF A CENTURY

To light Safety Fuse from one point in Secondary Blasting use ENSIGN-BICKFORD *Quarrycord*

Now you can use safety fuse and caps in multiple blockhole secondary blasting, with the added features of remote firing.

The lighting device is Quarrycord — a flexible water-resistant cord specially constructed to burn fast, at a speed of about one foot per second, with an external flame at the zone of burning. It is not affected by stray electrical currents, and is ideal for use during the thunderstorm season.

Fuse and caps are prepared in the usual way, with the addition of a connector crimped on the free end of the fuse. This connector protects the fuse powder train during rain storms, and is slotted to provide a firm, positive connection for the Quarrycord.

After the blockholes are loaded, the Quarrycord is run from hole to hole, and inserted into the slot of each connector. The top of the connector is pressed down over the Quarrycord, locking it firmly in place. The free end of the Quarrycord is then run out to a spot where it can be easily lighted.

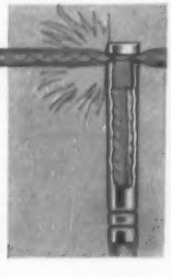
Plan your Quarrycord hookup so that the fuse in each blockhole is lighted before the first hole goes. Several groups of boulders can be prepared in this manner, and when all is in readiness, the blaster lights the Quarrycord for each group, and walks to a place of safety. Q-1

THE ENSIGN-BICKFORD COMPANY
SIMSBURY, CONNECTICUT
Manufacturers of Primacord-Bickford Detonating Fuse and Safety Fuse
Established 1836

Ensign-Bickford Quarrycord is packed on spools in 500 ft. lengths. See your explosives supplier or write us.

ENSIGN-BICKFORD *Quarrycord*

for lighting Safety Fuse in Secondary Blasting



IMPOSSIBLE WITHOUT EXPLOSIVES

In 50 years of mining operations by the Utah Copper Division of Kennecott Copper Corporation, Bingham Canyon has yielded more than 694,000,000 tons of copper ore. That's a lot of ore and it called for millions of pounds of industrial explosives, skillfully used, to break the ore loose from working faces, assure efficient shovel operations, and quick transportation to crushing and washing plants.

Explosives have been Hercules' business for 40 years. Wherever industrial explosives are needed, a Hercules technical representative can assist in the selection of the right explosives and blasting supplies for the job and recommend the most efficient methods to be used.

HERCULES POWDER COMPANY
INCORPORATED

Explosives Department, 990 Market Street, Wilmington 99, Del.

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XR54-9